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**Final Report  
NASA Goddard Space Flight Center  
Grant No. NNG04GJ09G**

**“Installation and Support for a CPI on the  
NASA WB-57 During MidCiX”**

**Period: 1 May 2004 – 30 April 2005**

*Activities focus on two primary goals:*

- 1. Participation in the MidCiX field campaign.*
- 2. Post-field campaign data processing and archiving.*

## 1. Participation in the MidCiX field campaign

SPEC personnel installed a SPEC Cloud Particle Imager (CPI) and a Forward Scattering Spectrometer Probe (SPP-100) with Droplet Measurement Technology's signal processing package on the WB-57. The system was similar to the installation on the same aircraft done for the Crystal-Face field project. Both instruments were run autonomously as required on that aircraft. **Figure 1** shows the instruments under the WB-57's right wing. **Figure 2** shows the pressurized box containing the computer and data acquisition system.

Two to three SPEC scientists and engineers participated at all times during the MidCiX field campaign. The CPI and SPP-100 were maintained and operated on the NASA WB-57. Quality control of the data was performed for each flight and Quicklook products were produced. Comparisons were made with other measurements and a short presentation was made at one of the science meetings. These are all posted on the MidCiX website (<http://www.met.utah.edu/cgi-bin/mace/MidCiX/MidCiX.cgi>) and a subset was displayed on the hanger boards also.

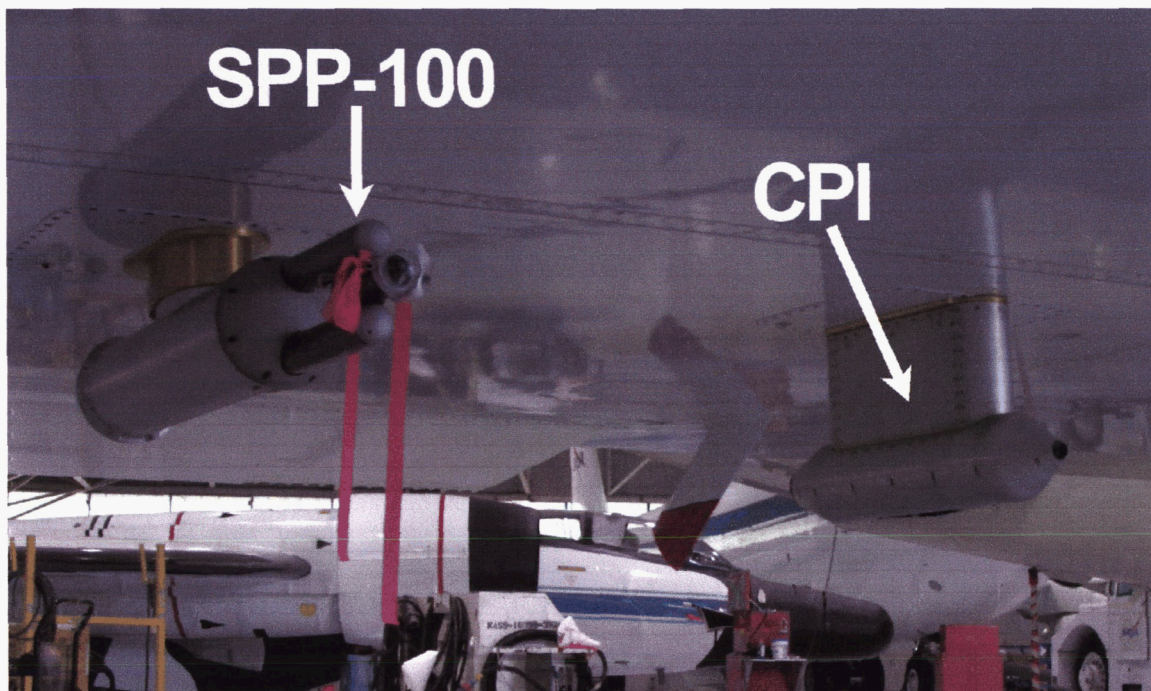


Figure 1: The SPP-100 and CPI mounted under the right wing of the WB-57 aircraft.





Figure 2: The computer and pressurized-box data-acquisition system for the CPI and SPP-100 inside the WB-57's right wind pod.

## **2. Post-field campaign data processing and archiving**

### **2.1 SPP-100 Data:**

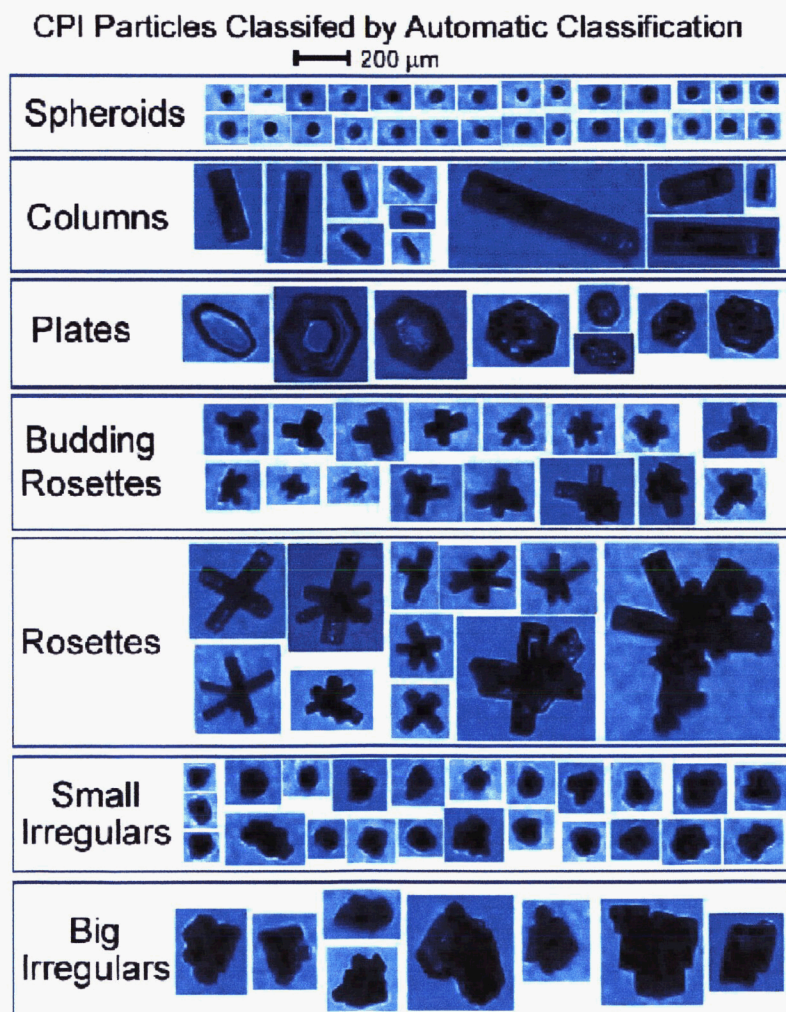
The SPP-100 measures the small Particle Size Distribution (PSD). The data are relatively straight forward. They are archived at 1 hz and there are 20 size bins from about 1 to 47 microns in diameter. The probe operated well on every flight and there is an archive data file for each flight.

### **2.2 CPI Data:**

The CPI data is considerably more complex than the SPP-100 data. The instrument also provides particle size distributions but these are created from processing of actual camera images of particles. The camera is triggered and thus the sampling is conditional which complicates quantification. Also the sample volume is small compared to most in-situ probes measuring the same size particles. Thus strict fixed frequency processing is not ideal and 1 Hz processing is usually meaningless. The data is most useful when it is processed using CPIView, which is software that was designed for displaying and processing CPI data. For each cloud segment of interest,

the user chooses the most appropriate averaging interval to use. However, to facilitate easier use of the data, particularly in conjunction with other measurements, a compromise was made and the CPI derived variables were calculated and archived at 0.1 hz time resolution. These were calculated and archived for all ten second periods that had at least 1 particle imaged. The PSD is archived into 33 fixed size bins from about 10 to 1000 microns. The PSD is not robust when only a few images were used however. The number of particles imaged and used in the PSD for each 10 second period is archived so that the user can have an idea of the statistics involved. Consecutive samples may be averaged together to create more meaningful PSDs.

Since CPI data is based on particle images in addition to deriving the basic cloud properties of concentration, extinction, IWC, and PSD, each of these was segregated according to the percentage contribution from the various crystal types. The habit classification was performed automatically using the following particle image characteristics: Length, Width, Area, Perimeter and radial harmonics. Example images from each habit class are shown in **Figure 3**.



**Figure 3:** Particle habit classes and example images.

**Table I** presents the flight days, the take off and landing times, and the data start and end times as well as the CPI status. The CPI worked from take off to landing but encountered no particles until the data start time. **Table II** shows the derived variables that have been archived. The archive file contains just the numbers that are bold in Table II. The non bold annotation in **Table II** is used here to show the definition of the derived variables.

Table 1: MidCiX flight days and times, and the CPI archived data time periods and status

Date(2005)	Take-off	Landing	Data Start	Data End	CPI-Status
April,19	16:53:00	21:51:00	18:38:40	21:12:40	Good
April,22	15:27:00	21:28:00	15:28:10	21:15:50	Good
April,27	15:05:00	21:00:00	15:03:40	20:57:10	Good
April,30	14:33:00	20:26:00	14:28:50	20:24:20	Good
May,2	16:16:00	22:02:00	16:06:10	21:59:40	Good
May,3	15:09:00	21:53:00	15:06:10	21:34:00	Good
May,5	14:46:00	20:30:00	14:43:50	20:29:40	Good
May,6	15:02:00	20:50:00	15:01:30	20:50:10	Good



Table II: Example of CPI archived derived variables. The actual archived numbers are in bold. The non-bold annotation is used here to define the variables. Start time is in seconds since midnight. Total\_N is the total number of imaged particles that went into the derived parameters. It is always an integer value. Units of concentration (Conc) are  $\# \text{ L}^{-1}$ , extinction (Extn) are  $\text{Km}^{-1}$ , ice water content (IWC) are  $\text{g m}^{-3}$ . The PSD units are  $\# \text{ L}^{-1} \mu\text{m}^{-1}$ . The PSD has 33 bins. The bins sizes are specified in the archive data file header. (All) refers to using all the imaged particles (>50) refers to the same calculation done using only particles larger than 50  $\mu\text{m}$  in size.

Start-time(s)	Interval(s)	total_N(all)	Conc(all)	Extn(all)	IWC(all)	total_N(>50)	Conc(>50)	Extn(>50)	IWC(>50)		
68920	10	174	630.3	1.883	0.0287	107	106.39	0.712	0.01447		
Habits:	Sphere	Column	Plate	Rossette	Bud-Ros	Small Irregular	Big Irregular				
Conc(all):	179.09	2.24	3.385	2.419	10.419	432.27	0				
Extn(all):	0.312	0.01	0.019	0.052	0.099	1.39	0				
IWC (all):	0.003	0	0	0.001	0.002	0.021	0				
Conc(>50):	0	2.24	3.855	2.419	10.419	87.456	0				
Extn(>50):	0	0.01	0.019	0.052	0.099	0.531	0				
IWC (>50):	0	0	0	0.001	0.002	0.01	0				
Particle	0.00	0.00	0.00	0.00	0.00	0.00	15.87	55.07	9.68	25.44	9.81
Size	4.72	3.34	2.40	1.54	0.37	0.37	0.10	0.02	0.00	0.03	0.02
Distribution	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

### 3. Summary

SPEC Incorporated supported the MidCiX field project under Grant No. NNG04GJ09G. SPEC personnel installed, maintained, and operated a CPI and SPP-100 on the WB-57. SPEC personnel also quality controlled the data, produced and displayed Quicklook data products, and made a presentation of scientific interest. After the field phase of the project, SPEC personnel processed and archived data from both instruments in accordance with the preferences of project participants.